UNIVERSITI PUTRA MALAYSIA

COMPOSTING OF OIL PALM EMPTY FRUIT BUNCHES WITH TRICHODERMA AND ORGANIC NITROGEN SUPPLEMENTATION AND THE EFFECTS OF THE COMPOST ON GROWTH OF TOMATO AND CORN

MUKHLIS.

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By

MUKHLIS

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

March 2006

Dedicated to

Allah S.W.T,

my late father Hj. Musdar,

my mother Hjh. Misra,

my wife Nani Astuty,

my children Netya Khairina,

Enny Khalisa, and

Gina Magfirah

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

COMPOSTING OF OIL PALM EMPTY FRUIT BUNCHES WITH *TRICHODERMA* AND ORGANIC NITROGEN SUPPLEMENTATION AND THE EFFECTS OF THE COMPOST ON GROWTH OF TOMATO AND CORN

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Chairman : Associate Professor Halimi Mohd. Saud, PhD

Faculty : Agriculture

Currently, Malaysia has 3.875 million ha of oil palm plantation. In total, about 90 million t of renewable biomass (trunks, fronds, shells, palm press fibre, and the empty fruit bunches) are produced annually. The empty fruit bunches (EFB) represent about 9 % of this total. EFB are the residue after the fresh fruit bunches (FFB) harvested from the oil palm are processed by the mill. About 22% of the processed FFB ends up as EFB which is a good source of macro and micro nutrients. In order to add value and to reduce the volume for easier application, composting of EFB has become increasingly popular. By composting the properties of the organic matter are easier to handle, more suitable as soil conditioners and organic fertilizer and do not adversely affect the environment. However, composting of EFB is generally time consuming. Therefore, the ability of *Trichoderma* and organic N was tested as activators that can accelerate the maturity and enhance the quality of oil palm EFB compost within a shorter period of time. In this study, screening of *Trichoderma* isolates was done *in vitro* for their ability to decompose cellulose and production of polyphenol oxidase. Six isolates were

selected to further study the *in vitro* decomposition of EFB and their phytopathogenicity against seed germination. Biodegradation of EFB supplemented with *Trichoderma* and organic N was examined, and the compost was tested for crop growth under field condition.

The results showed that most of the *Trichoderma* isolates exhibited an excellent growth performance to cellulose and tannic acid media and had a high ability to utilize different carbon sources. Of the 71 isolates tested, 56 isolates formed a clearing zone between 60-80 mm (75–100 % of Petri dish diameter) on Avicel substrate. Thirteen isolates had clearing zones between 40-60 mm (50-75 % of Petri dish diameter) and two isolates between 20-40 mm (25-50 % of Petri dish diameter). While on CMC substrate, 68 isolates formed a clear zone between 60-80 mm (75-100 % of Petri dish diameter) and three isolates formed between 40-60 mm (50-75 % of Petri dish diameter). Besides, 68 isolates could form dark brown color on tannic acid medium. Thus, they were able to decompose cellulose and synthesized polyphenol oxidase. Cluster analysis identified four clusters of the isolates with the ability to degrade cellulose and tannic acid. Based on this analysis, it was observed that 60 isolates had high ability to degrade carbon sources. From the EFB decomposition test, six selected isolates could decrease carbon and increased nitrogen contents at 3 until 6 weeks of decomposition thus leading to a decrease in C/N ratio and was significantly different compared to control. The decrease in C/N ratios of isolates T24 (*T. harzianum*) and T43 (*T. koningii*) were higher than those of other isolates. These isolates also did not posses any harmful characters detrimental to the crop plants, based on the plant performance against fungal biomass

(FBM) and fungal metabolite (FM) tests. Therefore, T24 and T43 were selected as the best potential isolates for rapid composting of EFB.

Biodegradation of EFB supplemented with *Trichoderma* and organic N (chicken manure) gave significant changes compared to *Trichoderma* or chicken manure alone. Supplementation *Trichoderma* and chicken manure resulted in a higher decrease in the percentage of cellulose (50.35 – 56.07) and hemicellulose (58.50 – 62.43). The C/N ratio, Germination Index of tomato seeds, and plant growth of tomato profiles showed that the compost had reached a satisfactory level of maturity on the 28th day of composting, and was acceptable for application to soil. The contents of N, P, K, Ca, and Mg of the 28 day-old EFB compost treated with *Trichoderma* and chicken manure were 2.19 - 2.32%, 1.35 - 1.48%, 3.99 - 4.08%, 3.49 - 3.67% and 1.41 - 1.63%, respectively, and have significant inorganic fertilizer replacement value for these major plant nutrients.

Under field condition, it showed that application of EFB compost significantly improved the soil chemical and biological characteristics and also significantly increased plant growth and yield. Application of EFB compost at a rate of 15 t/ha seemed to be optimum for dry weight of tomato on the first planting and grain yield of corn on the second planting. Results of this test also indicated that EFB compost and chicken manure at the same rate (7.5 t/ha), respectively induced a similar effect in the soil and plant growth. This means that EFB compost could be as good as chicken manure for crop cultivation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGKOMPOSAN TANDAN BUAH KOSONG KELAPA SAWIT DENGAN BEKALAN *TRICHODERMA* DAN NITROGEN ORGANIK DAN KESAN KOMPOS TERHADAP PERTUMBUHAN TOMATO DAN JAGUNG

Oleh

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Pengerusi : Professor Madya Halimi Mohd. Saud, PhD

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Pada masa kini, Malaysia mempunyai 3.875 juta ha ladang tanaman kelapa sawit. Secara keseluruhan, kira-kira 90 juta t biojisim yang dapat diperbaharui (batang, daun, tempurung, sabut, dan tandan buah kosong) dihasilkan setiap tahun. Tandan buah kosong (TBK) mewakili kira-kira 9% daripada jumlah tersebut. TBK adalah sisa selepas tandan buah segar yang dituai daripada pokok kelapa sawit diproses di kilang. Kira-kira 22% daripada tandan buah segar yang diproses adalah TBK yang merupakan sumber nutrient makro dan mikro yang baik. Dalam usaha untuk menambah nilai dan juga mengurangkan jumlah untuk memudahkan aplikasi, mengompos TBK telah menjadi semakin popular. Dengan mengompos, bahan organik adalah lebih mudah untuk diuruskan, lebih sesuai sebagai pembaikpulih tanah dan baja organik, serta tidak memberi kesan buruk kepada persekitaran. Bagaimanapun, proses mengompos TBK selalunya memakan masa yang lama. Untuk itu, kebolehan *Trichoderma* dan N organik

telah diuji sebagai pengaktif yang boleh mempercepatkan kematangan dan meningkatkan kualiti kompos TBK.

Dalam kajian ini, penskrinan isolat-isolat *Trichoderma* telah dibuat secara *in-vitro* untuk mengenalpasti kebolehan menguraikan selulosa dan menghasilkan polifenol oksidase. Enam isolat telah dipilih untuk kajian seterusnya untuk proses pereputan TBK secara *in-vitro* dan kesan fitopatogennya terhadap percambahan benih. Seterusnya, kebolehan *Trichoderma* dan N organik telah diuji terhadap biodegradasi TBK dan kompos yang dihasilkan telah diuji terhadap pertumbuhan tanaman di ladang.

Keputusan menunjukkan bahawa kebanyakan isolat-isolat *Trichoderma* tumbuh baik pada media selulosa dan asid tanik, serta mempunyai kebolehan yang tinggi untuk menggunakan sumber karbon yang berbeza. Bagi 71 isolat yang diuji, 56 isolat membentuk zon jernih antara 60-80 mm (75-100% diameter Petri dish) pada media Avicel. Tiga belas isolat mempunyai zon jernih antara 40-60 mm (50-75% diameter Petri dish) dan dua isolat antara 20-40 mm (25-50% diameter Petri dish). Pada media CMC, 68 isolat membentuk zon jernih antara 60-80 mm (75-100% diameter Petri dish) dan tiga isolat antara 40-60 mm (50-75% diameter Petri dish). Selain daripada itu, 68 isolat boleh membentuk warna coklat tua pada media tanik asid. Dengan itu, isolat-isolat ini mampu untuk mengurai selulosa dan menghasilkan polifenol oksidase. Analisis Kelompok membahagi empat kelompok isolat mengikut kebolehan mengurai selulosa dan tanik asid. Berdasar analisis ini, sebanyak 60 isolat mempunyai kebolehan tinggi untuk mengurai sumber karbon. Dalam ujian penguraian TBK, enam isolat terpilih boleh mengurangkan kandungan karbon dan meningkatkan kandungan nitrogen pada minggu ketiga sampai keenam tempoh penguraian. Kesan ini menyebabkan penurunan nisbah C/N dan berbeza secara signifikan berbanding kawalan. Bagaimanapun, penurunan nisbah C/N oleh isolat T24 (*T. harzianum*) dan T43 (*T. koningii*) adalah lebih tinggi berbanding isolat yang lain. Isolat ini tidak memberi kesan berbahaya kepada tanaman, berdasarkan tindak balas pada ujian biojisim kulat dan metabolit kulat. Oleh itu, isolat T24 dan T43 telah dipilih paling berpotensi untuk mempercepatkan pengkomposan.

Biodegradasi TBK yang dibekalkan *Trichoderma* dan N organik (tahi ayam) memberi perubahan yang signifikan berbanding *Trichoderma* atau tahi ayam sahaja. Bekalan *Trichoderma* dan tahi ayam menghasilkan penurunan yang lebih tinggi peratus selulosa (50.35 – 56.07) dan hemiselulosa (58.50 – 62.43). Nisbah C/N, Indeks percambahan benih tomato, pertumbuhan tanaman tomato menunjukkan bahawa kompos telah mencapai tahap kematangan pada hari ke 28 tempoh pengkomposan dan boleh diterima untuk aplikasi pada tanah. Kandungan N, P, K, Ca, dan Mg pada hari ke 28 usia kompos TBK yang dirawat dengan *Trichoderma* dan tahi ayam adalah 2.19 - 2.32%, 1.34 - 1.48%, 3.99 - 4.08%, 3.49 - 3.67%, dan 1.41 - 1.63% dan mempunyai nilai signifikan sebagai pengganti baja inorganik kepada nutrient utama tanaman.

Ujian kompos TBK terhadap pertumbuhan tanaman di ladang menunjukkan bahawa aplikasi kompos TBK telah meningkatkan ciri-ciri biologi dan kimia tanah, pertumbuhan dan hasil tanaman secara signifikan. Dalam hubungan dengan pertumbuhan tanaman (berat kering tanaman tomato pada penanaman pertama dan berat kering serta hasil biji jagung pada penanaman kedua), aplikasi kompos TBK pada kadar

15 t/ha adalah optimum. Keputusan daripada uji ini juga menunjukkan bahawa kompos TBK dan tahi ayam pada kadar yang sama (7.5 t/ha) memberikan kesan yang sama terhadap ciri-ciri tanah dan pertumbuhan tanaman.

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I certify that an Examination Committee has met on 28th Mac 2006 to conduct the final examination of Mukhlis on his Doctor of Philosophy thesis entitled "Composting of Oil Palm Empty Fruit Bunches with *Trichoderma* and Organic Nitrogen Supplementation and the Effects of the Compost on Growth of Tomato and Corn" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981). The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

MUKHLIS

Date 17 MAY 2006

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ABBREVIATIONS

CEC	cation exchange capacity
Cfu	colony forming unit
CMC	carboxymetil cellulose
CZ	clearing zone
D	diameter
EC	electrical conductivity
EFB	Empty fruit bunches
FBM	fungal biomass
FFB	fresh fruit bunches
FM	fungal metabolite
GI	germination index
MARDI	Malaysian Agriculture Research and Development Institute
M t	Mega tonne
NA	Nutrient agar medium
PDA	Potato dextrose agar medium
RBA	Rose Bengal agar medium
TOC	total organic carbon
TME	*Trichoderma* medium E